

SUGGESTIONS AS TO THE CONDITIONS PRECEDENT TO THE OCCURRENCE OF SUMMER THUNDERSTORMS, WITH SPECIAL REFERENCE TO THAT OF JUNE 14, 1914.

By JAMES FAIRGRIEVE.

(Quotations from abstract Quart. Jour. Roy. Meteorological Soc., 1918, vol. 44, pp. 245-252.)

A somewhat detailed study was made of the cloud distribution over the area on which the rainfall had been mapped, and attention was given to the pressure, winds, cloud, sunshine, temperature, and humidity over the whole of England on the day in question and on similar occasions. * * *

1. DISTRIBUTION OF CLOUD.

As observations of the amount of cloud are available only for the ordinary hours of observation the author was driven to an indirect method of estimating the prevalence of cloud at other times. He used the cards of the sunshine recorders for this purpose and established his standard by comparison with the observations at 9 a. m.

A study of the maps reveals the following points:

(a) The clouds, like the rain fields, tend to lie in belts. * * *

(b) Cloud belts foreshadowed the rain belts, sometimes by several hours. * * *

(c) The cloud belts tend to increase and decrease repeatedly over the same area. * * *

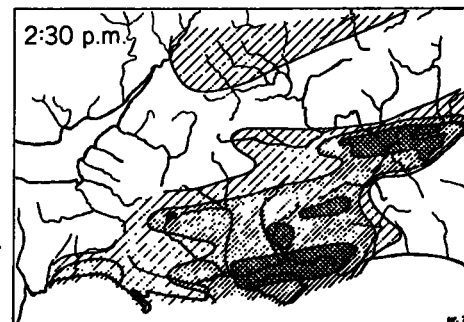
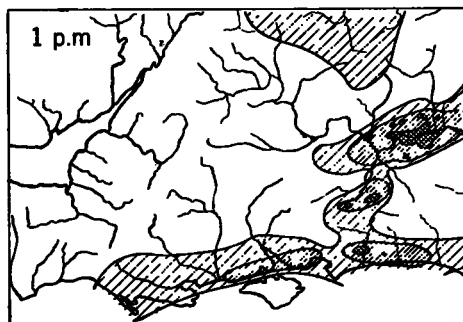
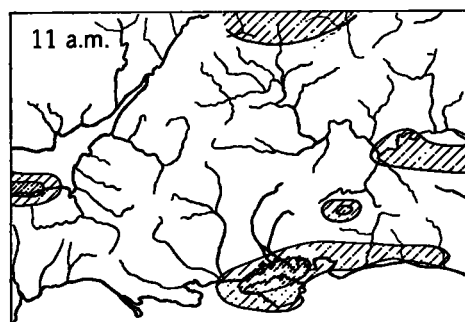


FIG 1.—Cloudiness and rain in south England, June 14, 1914. No shading=clear; light shading=partly cloudy; heavy shading=cloudy; cross-hatching=rain falling.

(d) As with the rain belts it was only on the south coast that the cloud belt extended westward quickly; it was not till between 2 and 3 p. m. that the sky north and northeast of Mid-Hampshire began to cloud extensively, though the cloud belt had extended along the south coast by 11 a. m.; by 5 p. m. the same region was showing signs that the cloud was becoming thinner than elsewhere.

(e) In the London district after the storm developed the cloud quickly thinned to the north and to the south-east. * * *

2. METEOROLOGICAL CONDITIONS OVER ENGLAND.

(a) *Pressure.*—On the 14th, and for some days previously, pressure was highest to the northwest of the British Isles in a ridge connecting the Atlantic anticyclone with an area of high readings over Scandinavia, and was low over France and Germany. * * * The general trend of the isobars was parallel to the belts of cloud and rain.

(b) *Surface winds.*—The winds at 9 a. m. * * * were generally from the northeast with some minor irregularities.

(c) *Cloud.*—* * * Over the northwest of England and Wales the sky was very clear, while the cloud was densest on the east coast. Over the central and southern part of the country a series of bands of cloud, roughly parallel to the isobars, is shown. The duration of sunshine for the day over the British Isles has similar features.

(d) *Dew point.*—The temperature of the dew point at 9 a. m. was worked out for England and Wales; the highest values were in the southeast and lowest in the northwest. Just north of London the dew point was over 62° F., and it decreased to less than 42° in northern Lancashire. The plottings were unusually accordant.

(e) *Temperature.*—At 9 a. m. the distribution of temperature was similar to that of cloud; but it is doubtful whether the correspondence is of importance. It is probably due to the fact that where the sun had been shining for some hours the surface temperature was raised.

(f) *Minimum temperature.*—The minimum temperatures of the previous night were also plotted. The author suggests that some of the irregularities in the direction of the wind are associated with the areas in which temperature had been lowest a few hours earlier.

3. CONDITIONS ON OTHER THUNDERSTORM DAYS.

The author has also examined the incidence of minimum temperature on other days on which thunderstorms occurred, including May 31, 1911, the "Derby Day" thunderstorm, and July 1, 2, 3, and 4, 1914. The inquiry suggests some connection between the distribution of minimum temperature and subsequent thunderstorm phenomena, but the indications are not very definite.

4. THE LONDON DISTRICT.

(a) *Hail.*—About 70 observers in the London district sent in reports on falls of hail. Very little hail fell north of the river, and none of any consequence in the southwest of the storm area. The hail fell in more or less detached areas, and seems to have fallen in four or five bursts and not over large areas at one time. * * *

(b) *Wind movement.*—Outside the immediate storm area the general northeasterly direction of the wind was maintained, but the winds were probably rather lighter in the south than to the north. Several irregularities are reported within the area. * * *

(c) *Cloud movement*.—The evidence as to wind movement in the upper air is very scanty, but what there is is interesting. To the north of the storm, at Barnet, the lower clouds were consistently from the northeast or east-northeast, the higher clouds, said to be cirrus, being from the east or south-southeast. "From 2 to 8.30 a constant procession of embryo cumulus passed south of Barnet and seemed to attain development south of that place." Only one important cumulus passed north of Barnet. This agrees with the author's own recollections of the occurrences seen from New Southgate, a little nearer the storm area. At Barnet by 1 p. m. a large pile of cumulus with brilliant protuberances was seen to the south-southeast, beginning to "fan" slightly at the top. It may be noticed that this time agrees with the first fall of hail on the north of the storm.

From Warlingham on the south of the storm magnificent thunderheads were seen at 2 p. m. to the north. This again agrees with the time when hail occurred in the center of the storm. Later, a large anvil-shaped cloud rose up behind the other clouds. From Purley about 3.30 a large cloud pillar was observed 18° east of north and 25° high. Assuming that this was 8 or 9 miles away, the height would be about 3 miles. This rose and merged into the upper cloud.

Within the storm or on its southern margin at New Malden the lower thundercloud moved very slowly from east-northeast, but the "upper cloud" was seen during a lull in the storm to be moving from the south.

5. CONCLUSIONS.

In the concluding section of the paper the author discusses the bearings of the facts elucidated on the causes of thunderstorms, and also on the causes responsible for starting storms when conditions are favorable, but he points out that the connection between the facts and the views which he adopts is not very clearly made out. He agrees with Lieut. Douglas that the conditions necessary for summer thunderstorms are produced at some height above the surface,¹ say about 3,000 feet, that they may be started by conditions below that height, and that surface wind phenomena and temperature phenomena, such as the fall of temperature almost simultaneously with the beginning of the storm, are the results and not causes. It would seem probable that a necessary condition for the occurrence of a thunderstorm is that the temperature should decrease at a rate not less than normal, i. e., that the lapse rate should be about 3.5° F. per 1,000 feet for a considerable distance upward, and refers to a suggestion by Lieut. Douglas that this should occur for a height of 6,000 feet from half a mile above the ground. Cirrus, possibly false cirrus, is usually, if not always, present, and when the cumulus reaches a height of 3 to 4 miles its top spreads out. * * *

The author thinks that local surface conditions, such as the relief of the ground, may determine the start of a

storm; the high ground of Leith Hill and Hindhead may have given a start to the storm in that district.

The marked belting or banding shown on several of the charts of different phenomena on the 14th suggests the possibility of some form of wave action, and the same idea is supported by the lines of cloud belts during this storm, and also by the maps of rain distribution on thunderstorm days with which readers of British Rainfall are familiar, and which frequently show splashes of rain distributed in lines across the country.¹

If this is so, an upward movement over the area of the rain field is postulated, and this must be initiated by descent of cooler air on the outside, but this normally takes place above the lowest half mile in the atmosphere. Eventually, of course, some surface air does move inward, giving rise to the cyclonic circulation noticed on the outskirts of the storm, while on the whole calms prevail within the storm area. Later this calm is occasionally broken by violent gusts.

The first of "cyclonic" phase seems fairly clear. There seems, however, to be a second phase in any thunderstorm which remains for an hour or two over the same area. On the one hand the rain field seems to break up into two parallel belts, and on the other the surface wind seems to blow from the storm. It seems to be the case also, if we can generalize from two investigations, that the more vigorous of the two belts of rain field into which the storm breaks is on the side from which the wind is naturally coming. On June 14, 1914, the wind on that side, the northern, had a much greater surface velocity. This seems to suggest that the reason for the greater activity has to do with a greater supply of air on that side. As far as any surface observation is concerned this air seems to disappear. The logical inference is that it must be rising. It is possible that the projections of the rain field northwards, e. g., at about 3.45, along neither of the dominant axes may be due to the rising of this air in patches rather than along a continuous front.

As to the breaking up of the storm into two belts the following suggestions have been made. When rain or hail forms, it is said, pressure will first decrease immediately below the point of formation. The rain on falling will reach a terminal velocity. The air through which it passes will be cooled and contract, i. e., become heavier, and pressure will increase. At first these winds will tend to flow inward, and later they will tend to flow out. On this assumption the violent gusts at the surface in the center of the storm during the later stages are due to the descending air. * * * All this goes to show that the rain area was a local high pressure area during the later stages of the storm.

In any case the evidence of the surface winds must be taken into account. As these seem in the later stages to be blowing from the storm it is fair to infer that the pressure is greater along the middle line than on the outskirts.

¹ Douglas, C. K. M., "The lapse-line and its relation to cloud formation," Edinburgh, J. Scot. Meteor. Soc., 17, 1917, pp. 133-147.

¹ Not necessarily from moving storms.—C. F. B.

WIND STRATIFICATION NEAR A LARGE THUNDERSTORM.

By LESLIE A. WARREN.

[Dated: Weather Bureau Aerological Station, Broken Arrow, Okla., June 25, 1919.]

The accompanying horizontal projection curve of a pilot balloon ascension begun shortly after 3 p. m. on June 20, 1919, at the Broken Arrow Aerological Station (fig. 1) reveals an unusual and very interesting wind condition. The balloon in attaining an altitude of 7,000

meters made three nearly complete reversals in horizontal direction, corresponding to two counter-clockwise whirls which are evident upon the projection. The balloon, after release was carried upward in a light easterly wind until an altitude of 1,500 meters was reached where